科雷丁技术（山西）有限公司
Cladding Technology (Shanxi) Co., Ltd.
增材制造 · TIG 堆焊 · MIG 堆焊 · 精密焊接 · 表面强化 · 再制造修复

Cladding-Technology-Shanxi-Co.,-Ltd-CLADDING-ITP-018-Cladding-Large-Diameter-Flange-ITP

大口径法兰堆焊层间控制、热处理与整体检验计划

Inspection and Test Plan for Large Diameter Flange Cladding Layer Control, Heat Treatment and Overall Inspection

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1. 目的 / Purpose

本检验计划旨在规范科雷丁技术（山西）有限公司大口径法兰堆焊作业过程中的层间控制、热处理及整体检验要求，确保法兰堆焊层质量符合设计图纸、技术协议及 GB/T 19453、NB/T 47014 等相关标准要求，实现增材制造与精密堆焊工艺的质量受控。

This inspection and test plan is established to regulate the layer control, heat treatment and overall inspection requirements during the large diameter flange cladding operation of CLADDING Technology (Shanxi) Co., Ltd., ensuring that the flange cladding layer quality complies with design drawings, technical agreements and relevant standard requirements such as GB/T 19453, NB/T 47014, etc., and achieving quality control of additive manufacturing and precision cladding processes.

2. 适用范围 / Scope

本计划适用于公司承接的大口径法兰（DN300 及以上）TIG 堆焊、MIG 堆焊及电弧增材制造项目，涵盖法兰堆焊前的基材准备、堆焊层间控制、焊后热处理及成品整体检验全过程。

This plan applies to large diameter flange (DN300 and above) TIG cladding, MIG cladding and arc additive manufacturing projects undertaken by the company, covering the entire process from base material preparation before flange cladding, interlayer control during cladding, post-weld heat treatment to finished product overall inspection.

3. 职责 / Responsibilities

部门/岗位	职责描述
工艺部	编制焊接工艺规程，确定堆焊层间温度控制参数，制定热处理工艺方案
生产部	执行堆焊作业，记录层间温度，配合检验工作
质量部	实施过程检验与最终检验，出具检验报告
设备部	确保堆焊设备、热处理设备正常运行
技术部	审核工艺文件，处理技术质量问题

Department/Position	Responsibility Description
Process Dept.	Develop welding procedure specifications, determine interlayer temperature control parameters, formulate heat treatment process plans

Production Dept.	Execute cladding operations, record interlayer temperature, cooperate with inspection work
Quality Dept.	Implement process inspection and final inspection, issue inspection reports
Equipment Dept.	Ensure normal operation of cladding equipment and heat treatment equipment
Technology Dept.	Review process documents, handle technical quality issues

4. 管理内容与程序 / Management Content and Procedures

4.1 检验计划总览 / Inspection Plan Overview

序号	检验项目	检验内容	检验方法	检验时机	合格标准	记录文件
1	基材检查	材质、尺寸、表面状态	目视、测量	堆焊前	符合图纸要求	基材检验记录
2	焊材检查	型号、规格、外观	目视、核对	堆焊前	符合 WPS 要求	焊材检验记录
3	焊接工艺评定	工艺参数验证	试件焊接	批量生产前	符合评定标准	PWQR
4	层间温度控制	温度监测	测温仪	每层堆焊前	符合工艺要求	层间温度记录
5	层间清理	飞溅、氧化皮清除	目视	每层堆焊后	表面清洁	层间清理记录
6	堆焊层外观	成型、缺陷	目视	每层堆焊后	无超标缺陷	外观检验记录
7	堆焊层尺寸	厚度、宽度	测量	每层堆焊后	符合图纸要求	尺寸检验记录
8	无损检测	内部缺陷	UT/MT/PT	堆焊完成后	符合验收标准	NDT 报告
9	焊后热处理	温度、保温时间	测温、计时	堆焊完成后	符合热处理工艺	热处理记录

10	硬度检测	堆焊层及热影响区硬度	硬度计	热处理后	符合技术要求	硬度检测报告
11	化学成分分析	堆焊层成分	光谱分析	热处理后	符合材料标准	化学成分报告
12	力学性能试验	拉伸、弯曲	试验	热处理后	符合标准要求	力学性能报告
13	最终尺寸检验	整体尺寸精度	测量	热处理后	符合图纸要求	最终检验记录
14	成品外观检验	表面质量	目视	最终	符合验收标准	成品检验报告

No.	Inspection Item	Inspection Content	Inspection Method	Inspection Timing	Acceptance Criteria	Record Document
1	Base Material Check	Material, dimension, surface condition	Visual, Measurement	Before cladding	Comply with drawing requirements	Base Material Inspection Record
2	Welding Material Check	Type, specification, appearance	Visual, Verification	Before cladding	Comply with WPS requirements	Welding Material Inspection Record
3	Welding Procedure Qualification	Process parameter verification	Test coupon welding	Before mass production	Comply with qualification standard	PWQR
4	Interlayer Temperature Control	Temperature monitoring	Thermometer	Before each layer cladding	Comply with process requirements	Interlayer Temperature Record
5	Interlayer Cleaning	Spatter, oxide removal	Visual	After each layer cladding	Clean surface	Interlayer Cleaning Record
6	Cladding Layer Appearance	Formation, defects	Visual	After each layer cladding	No excessive defects	Appearance Inspection Record
7	Cladding Layer	Thickness, width	Measurement	After each layer	Comply with drawing	Dimension Inspection

	Dimension			cladding	requirements	Record
8	Non-Destructive Testing	Internal defects	UT/MT/PT	After cladding	Comply with acceptance standard	NDT Report
9	Post-Weld Heat Treatment	Temperature, holding time	Temperature measurement, Timing	After cladding	Comply with heat treatment process	Heat Treatment Record
10	Hardness Test	Hardness of cladding layer and HAZ	Hardness tester	After heat treatment	Comply with technical requirements	Hardness Test Report
11	Chemical Composition Analysis	Cladding layer composition	Spectral analysis	After heat treatment	Comply with material standard	Chemical Composition Report
12	Mechanical Property Test	Tensile, bending	Test	After heat treatment	Comply with standard requirements	Mechanical Property Report
13	Final Dimension Inspection	Overall dimensional accuracy	Measurement	After heat treatment	Comply with drawing requirements	Final Inspection Record
14	Finished Product Appearance Inspection	Surface quality	Visual	Final	Comply with acceptance standard	Finished Product Inspection Report

4.2 基材检查 / Base Material Inspection

4.2.1 检验内容 / Inspection Content

大口径法兰堆焊前，应对基材进行全面检查，包括：

Before large diameter flange cladding, the base material shall be comprehensively inspected, including:

- 材质证明核对：确认法兰基材材质与设计要求一致，材质证明文件齐全
- 尺寸检查：法兰外径、内径、厚度、螺栓孔等尺寸符合图纸要求
- 表面状态检查：堆焊区域表面无裂纹、夹渣、严重锈蚀等缺陷
- 坡口准备：堆焊区域坡口形式、尺寸符合工艺要求

- Material certificate verification: Confirm that the flange base material matches the design requirements and material certificates are complete
- Dimension inspection: Flange outer diameter, inner diameter, thickness, bolt holes and other dimensions comply with drawing requirements
- Surface condition inspection: The cladding area surface has no cracks, inclusions, severe rust or other defects
- Groove preparation: Groove form and dimensions of the cladding area comply with process requirements

4.2.2 合格标准 / Acceptance Criteria

检验项目	合格标准
材质	与设计要求一致，材质证明齐全
外径	符合图纸尺寸及公差要求
内径	符合图纸尺寸及公差要求
厚度	符合图纸尺寸及公差要求
表面状态	无裂纹、夹渣、严重锈蚀，粗糙度 Ra≤6.3μm
坡口	坡口角度、钝边尺寸符合工艺要求

Inspection Item	Acceptance Criteria
Material	Consistent with design requirements, material certificates complete
Outer Diameter	Comply with drawing dimensions and tolerance requirements
Inner Diameter	Comply with drawing dimensions and tolerance requirements
Thickness	Comply with drawing dimensions and tolerance requirements
Surface Condition	No cracks, inclusions, severe rust, roughness Ra≤6.3μm
Groove	Groove angle, root face dimensions comply with process requirements

4.3 焊材检查 / Welding Material Inspection

4.3.1 检验内容 / Inspection Content

- 焊丝型号核对：确认焊丝型号与 WPS 要求一致
- 焊丝外观检查：表面无锈蚀、油污、机械损伤
- 焊丝直径测量：直径偏差在允许范围内
- 保护气体检查：气体纯度、流量符合工艺要求
- 焊丝烘干记录：低氢型焊材按要求烘干
- Welding wire type verification: Confirm that the welding wire type matches WPS requirements
- Welding wire appearance inspection: Surface has no rust, oil contamination, mechanical damage
- Welding wire diameter measurement: Diameter deviation within allowable range
- Shielding gas inspection: Gas purity and flow rate comply with process requirements
- Welding wire baking record: Low-hydrogen type welding materials baked as required

4.3.2 合格标准 / Acceptance Criteria

检验项目	合格标准
焊丝型号	与 WPS 要求一致
焊丝外观	无锈蚀、油污、机械损伤
焊丝直径	偏差≤±0.02mm
保护气体纯度	Ar≥99.99%
保护气体流量	符合工艺要求（TIG：8-12L/min，MIG：15-25L/min）
焊丝烘干	低氢型焊材按 350-400℃烘干 1-2 小时

Inspection Item	Acceptance Criteria
Welding Wire Type	Consistent with WPS requirements
Welding Wire Appearance	No rust, oil contamination, mechanical damage
Welding Wire Diameter	Deviation ≤±0.02mm
Shielding Gas Purity	Ar≥99.99%
Shielding Gas Flow Rate	Comply with process requirements (TIG: 8-12L/min, MIG: 15-25L/min)
Welding Wire Baking	Low-hydrogen type welding materials baked at 350-400℃ for 1-2 hours

4.4 层间温度控制 / Interlayer Temperature Control

4.4.1 控制要求 / Control Requirements

大口径法兰堆焊过程中，层间温度控制是保证堆焊层质量的关键环节。根据堆焊材料特性及工艺要求，层间温度控制标准如下：

During the large diameter flange cladding process, interlayer temperature control is a key link to ensure cladding layer quality. According to the cladding material characteristics and process requirements, the interlayer temperature control standards are as follows:

堆焊材料类型	层间温度控制范围	测温方法	测温位置
不锈钢堆焊层	150-250℃	红外测温仪	堆焊层表面距焊缝边缘 10mm 处
镍基合金堆焊层	100-200℃	红外测温仪	堆焊层表面距焊缝边缘 10mm 处
钴基合金堆焊层	150-300℃	红外测温仪	堆焊层表面距焊缝边缘 10mm 处
碳化钨堆焊层	200-350℃	红外测温仪	堆焊层表面距焊缝边缘 10mm 处

Cladding Material Type	Interlayer Temperature Control Range	Temperature Measurement Method	Measurement Position
Stainless Steel Cladding Layer	150-250℃	Infrared Thermometer	10mm from weld edge on cladding layer surface
Nickel-Based Alloy Cladding Layer	100-200℃	Infrared Thermometer	10mm from weld edge on cladding layer surface
Cobalt-Based Alloy Cladding Layer	150-300℃	Infrared Thermometer	10mm from weld edge on cladding layer surface
Tungsten Carbide Cladding Layer	200-350℃	Infrared Thermometer	10mm from weld edge on cladding layer surface

4.4.2 控制程序 / Control Procedure

1. 每层堆焊前，使用红外测温仪测量堆焊区域温度

2. 当层间温度超过上限时，停止堆焊，自然冷却至规定范围内再继续堆焊
3. 当层间温度低于下限时，可适当预热或缩短冷却时间
4. 每层堆焊的层间温度应记录在《层间温度控制记录表》中
5. 层间温度记录应包含：层号、测量时间、测量温度、操作者
6. Before each layer cladding, measure the cladding area temperature using an infrared thermometer
7. When the interlayer temperature exceeds the upper limit, stop cladding, allow natural cooling to the specified range before continuing cladding
8. When the interlayer temperature is below the lower limit, appropriate preheating or shortened cooling time may be applied
9. The interlayer temperature of each cladding layer shall be recorded in the "Interlayer Temperature Control Record"
10. The interlayer temperature record shall include: layer number, measurement time, measured temperature, operator

4.4.3 合格标准 / Acceptance Criteria

- 层间温度在工艺规定范围内
- 温度记录完整、准确
- 超温处理措施得当
- Interlayer temperature within the process specified range
- Temperature records complete and accurate
- Over-temperature handling measures appropriate

4.5 层间清理 / Interlayer Cleaning

4.5.1 清理要求 / Cleaning Requirements

每层堆焊完成后，应对堆焊层表面进行清理，具体要求如下：

After each layer cladding is completed, the cladding layer surface shall be cleaned, with specific requirements as follows:

- 清除堆焊层表面的飞溅、氧化皮
- 检查堆焊层表面质量，发现缺陷及时处理
- 清理工具：钢丝刷、角磨机（配不锈钢丝轮或砂轮片）
- 清理后表面应清洁，无杂物
- Remove spatter and oxide scale from the cladding layer surface
- Inspect cladding layer surface quality, handle defects promptly when found
- Cleaning tools: Wire brush, angle grinder (equipped with stainless steel wire wheel or grinding wheel)
- The cleaned surface shall be clean and free of debris

4.5.2 合格标准 / Acceptance Criteria

- 堆焊层表面无飞溅、氧化皮
- 表面清洁，无杂物
- 清理后表面粗糙度 Ra≤12.5μm
- No spatter or oxide scale on cladding layer surface
- Surface clean, free of debris
- Surface roughness after cleaning Ra≤12.5μm

4.6 堆焊层外观检验 / Cladding Layer Appearance Inspection

4.6.1 检验内容 / Inspection Content

每层堆焊完成后，应对堆焊层外观进行检验，检验内容包括：

After each layer cladding is completed, the cladding layer appearance shall be inspected, with inspection content including:

- 堆焊层成型质量：焊缝波纹均匀，过渡平滑
- 表面缺陷检查：裂纹、气孔、夹渣、未熔合等
- 堆焊层宽度：符合工艺要求
- 堆焊层高度：符合工艺要求
- 咬边检查：咬边深度不超过规定值
- Cladding layer formation quality: Uniform weld ripples, smooth transition
- Surface defect inspection: Cracks, porosity, inclusions, lack of fusion, etc.
- Cladding layer width: Comply with process requirements
- Cladding layer height: Comply with process requirements
- Undercut inspection: Undercut depth not exceeding specified value

4.6.2 合格标准 / Acceptance Criteria

检验项目	合格标准
焊缝成型	波纹均匀，过渡平滑
裂纹	不允许存在
气孔	单孔直径≤1.5mm，间距≥3 倍孔径
夹渣	单处长度≤5mm，深度≤0.5mm
咬边	深度≤0.5mm，连续长度≤100mm
未熔合	不允许存在
堆焊层宽度	符合工艺要求，偏差≤±2mm

堆焊层高度	符合工艺要求，偏差≤±0.5mm

Inspection Item	Acceptance Criteria
Weld Formation	Uniform ripples, smooth transition
Cracks	Not allowed
Porosity	Single pore diameter ≤1.5mm, spacing ≥3 times pore diameter
Inclusions	Single length ≤5mm, depth ≤0.5mm
Undercut	Depth ≤0.5mm, continuous length ≤100mm
Lack of Fusion	Not allowed
Cladding Layer Width	Comply with process requirements, deviation ≤±2mm
Cladding Layer Height	Comply with process requirements, deviation ≤±0.5mm

4.7 堆焊层尺寸检验 / Cladding Layer Dimension Inspection

4.7.1 检验内容 / Inspection Content

- 堆焊层厚度：使用千分尺或超声波测厚仪测量
- 堆焊层宽度：使用卡尺测量
- 堆焊层高度：使用高度尺测量
- 堆焊层总厚度：符合图纸要求
- Cladding layer thickness: Measure using micrometer or ultrasonic thickness gauge
- Cladding layer width: Measure using caliper
- Cladding layer height: Measure using height gauge
- Total cladding layer thickness: Comply with drawing requirements

4.7.2 合格标准 / Acceptance Criteria

检验项目	合格标准
单层堆焊厚度	符合工艺要求，偏差≤±0.2mm
堆焊层宽度	符合工艺要求，偏差≤±2mm
堆焊层总厚度	符合图纸要求，偏差≤±0.5mm

堆焊层均匀性	厚度偏差≤±10%

Inspection Item	Acceptance Criteria
Single Layer Cladding Thickness	Comply with process requirements, deviation ≤±0.2mm
Cladding Layer Width	Comply with process requirements, deviation ≤±2mm
Total Cladding Layer Thickness	Comply with drawing requirements, deviation ≤±0.5mm
Cladding Layer Uniformity	Thickness deviation ≤±10%

4.8 无损检测 / Non-Destructive Testing

4.8.1 检测方法 / Inspection Methods

根据堆焊层材料及厚度，选择合适的无损检测方法：

Select appropriate non-destructive testing methods according to cladding layer material and thickness:

堆焊层材料	检测方法	检测比例
不锈钢堆焊层	渗透检测（PT）+超声波检测（UT）	100%
镍基合金堆焊层	渗透检测（PT）+超声波检测（UT）	100%
钴基合金堆焊层	渗透检测（PT）+超声波检测（UT）	100%
碳化钨堆焊层	渗透检测（PT）+目视检测（VT）	100%

Cladding Layer Material	Inspection Method	Inspection Ratio
Stainless Steel Cladding Layer	Penetrant Testing (PT) + Ultrasonic Testing (UT)	100%
Nickel-Based Alloy Cladding Layer	Penetrant Testing (PT) + Ultrasonic Testing (UT)	100%

Cobalt-Based Alloy Cladding Layer	Penetrant Testing (PT) + Ultrasonic Testing (UT)	100%
Tungsten Carbide Cladding Layer	Penetrant Testing (PT) + Visual Testing (VT)	100%

4.8.2 合格标准 / Acceptance Criteria

缺陷类型	合格标准
裂纹	不允许存在
未熔合	不允许存在
未焊透	不允许存在
气孔	单孔直径≤1.5mm，密集气孔面积≤50mm²
夹渣	单处长度≤5mm，深度≤0.5mm
咬边	深度≤0.5mm

Defect Type	Acceptance Criteria
Cracks	Not allowed
Lack of Fusion	Not allowed
Incomplete Penetration	Not allowed
Porosity	Single pore diameter ≤1.5mm, dense porosity area ≤50mm²
Inclusions	Single length ≤5mm, depth ≤0.5mm
Undercut	Depth ≤0.5mm

4.9 焊后热处理 / Post-Weld Heat Treatment

4.9.1 热处理目的 / Heat Treatment Purpose

焊后热处理的主要目的：

The main purposes of post-weld heat treatment:

- 消除焊接残余应力
- 改善堆焊层及热影响区的组织和性能

- 提高堆焊层的韧性和抗裂性
- 稳定堆焊层尺寸
- Eliminate welding residual stress
- Improve the structure and properties of cladding layer and heat affected zone
- Improve the toughness and crack resistance of cladding layer
- Stabilize cladding layer dimensions

4.9.2 热处理工艺 / Heat Treatment Process

堆焊层材料	热处理温度	保温时间	升温速率	降温速率
不锈钢堆焊层	1050-1100℃	1-2 小时/25mm	≤200℃/h	≤150℃/h
镍基合金堆焊层	980-1050℃	1-2 小时/25mm	≤200℃/h	≤150℃/h
钴基合金堆焊层	950-1000℃	1-2 小时/25mm	≤200℃/h	≤150℃/h
碳化钨堆焊层	800-850℃	1-2 小时/25mm	≤200℃/h	≤150℃/h

Cladding Layer Material	Heat Treatment Temperature	Holding Time	Heating Rate	Cooling Rate
Stainless Steel Cladding Layer	1050-1100℃	1-2 hours/25mm	≤200℃/h	≤150℃/h
Nickel-Based Alloy Cladding Layer	980-1050℃	1-2 hours/25mm	≤200℃/h	≤150℃/h
Cobalt-Based Alloy Cladding Layer	950-1000℃	1-2 hours/25mm	≤200℃/h	≤150℃/h
Tungsten Carbide Cladding Layer	800-850℃	1-2 hours/25mm	≤200℃/h	≤150℃/h

4.9.3 热处理程序 / Heat Treatment Procedure

11. 装炉：将堆焊完成的法兰装入热处理炉，确保法兰与炉壁间距≥100mm
12. 升温：按规定的升温速率加热至热处理温度
13. 保温：在热处理温度下保温规定时间
14. 降温：按规定的降温速率冷却至 200℃以下出炉
15. 记录：记录热处理全过程的温度、时间数据

16. Loading: Load the cladded flange into the heat treatment furnace, ensure the distance between flange and furnace wall ≥100mm
17. Heating: Heat to the heat treatment temperature at the specified heating rate
18. Holding: Hold at the heat treatment temperature for the specified time
19. Cooling: Cool to below 200℃ at the specified cooling rate before unloading
20. Recording: Record temperature and time data throughout the heat treatment process

4.9.4 合格标准 / Acceptance Criteria

- 热处理温度在工艺规定范围内
- 保温时间符合工艺要求
- 升温、降温速率符合工艺要求
- 热处理记录完整、准确
- Heat treatment temperature within the process specified range
- Holding time complies with process requirements
- Heating and cooling rates comply with process requirements
- Heat treatment records complete and accurate

4.10 硬度检测 / Hardness Test

4.10.1 检测要求 / Test Requirements

热处理完成后，应对堆焊层及热影响区进行硬度检测：

After heat treatment is completed, hardness testing shall be performed on the cladding layer and heat affected zone:

- 检测位置：堆焊层表面、堆焊层与基材交界处、热影响区
- 检测方法：洛氏硬度（HRC）或维氏硬度（HV）
- 检测点数：每 100mm²不少于 1 个点
- Test positions: Cladding layer surface, junction of cladding layer and base material, heat affected zone
- Test method: Rockwell hardness (HRC) or Vickers hardness (HV)
- Test points: Not less than 1 point per 100mm²

4.10.2 合格标准 / Acceptance Criteria

堆焊层材料	硬度要求
不锈钢堆焊层	HB≤250
镍基合金堆焊层	HB≤250
钴基合金堆焊层	HB≤300

碳化钨堆焊层	HB≥400

Cladding Layer Material	Hardness Requirement
Stainless Steel Cladding Layer	HB≤250
Nickel-Based Alloy Cladding Layer	HB≤250
Cobalt-Based Alloy Cladding Layer	HB≤300
Tungsten Carbide Cladding Layer	HB≥400

4.11 化学成分分析 / Chemical Composition Analysis

4.11.1 分析要求 / Analysis Requirements

热处理完成后，应对堆焊层进行化学成分分析：

After heat treatment is completed, chemical composition analysis shall be performed on the cladding layer:

- 分析位置：堆焊层表面
- 分析方法：光谱分析
- 分析元素：主要合金元素含量
- Analysis position: Cladding layer surface
- Analysis method: Spectral analysis
- Analysis elements: Content of main alloy elements

4.11.2 合格标准 / Acceptance Criteria

堆焊层化学成分应符合相应材料标准要求，具体标准如下：

The chemical composition of the cladding layer shall comply with the corresponding material standard requirements, with specific standards as follows:

堆焊层材料	执行标准	主要元素要求
不锈钢堆焊层	GB/T 20878	Cr≥18%, Ni≥8%
镍基合金堆焊层	GB/T 29512	Ni≥58%, Cr≥20%
钴基合金堆焊层	GB/T 29512	Co≥55%, Cr≥25%
碳化钨堆焊层	技术协议	WC≥70%, Co≥20%

Cladding Layer Material	Applicable Standard	Main Element Requirements
Stainless Steel Cladding Layer	GB/T 20878	Cr≥18%, Ni≥8%
Nickel-Based Alloy Cladding Layer	GB/T 29512	Ni≥58%, Cr≥20%
Cobalt-Based Alloy Cladding Layer	GB/T 29512	Co≥55%, Cr≥25%
Tungsten Carbide Cladding Layer	Technical Agreement	WC≥70%, Co≥20%

4.12 力学性能试验 / Mechanical Property Test

4.12.1 试验要求 / Test Requirements

热处理完成后，应对堆焊层进行力学性能试验：

After heat treatment is completed, mechanical property tests shall be performed on the cladding layer:

- 拉伸试验：测定堆焊层的抗拉强度、屈服强度、延伸率
- 弯曲试验：测定堆焊层的弯曲性能
- 冲击试验：测定堆焊层的冲击韧性
- Tensile test: Determine the tensile strength, yield strength, elongation of cladding layer
- Bending test: Determine the bending properties of cladding layer
- Impact test: Determine the impact toughness of cladding layer

4.12.2 合格标准 / Acceptance Criteria

堆焊层材料	抗拉强度(MPa)	屈服强度(MPa)	延伸率(%)	冲击功(J)
不锈钢堆焊层	≥450	≥205	≥30	≥27
镍基合金堆焊层	≥550	≥240	≥30	≥27
钴基合金堆焊层	≥600	≥250	≥25	≥27
碳化钨堆焊层	≥700	≥300	≥15	≥20

Cladding Layer Material	Tensile Strength (MPa)	Yield Strength (MPa)	Elongation (%)	Impact Energy (J)
Stainless Steel Cladding Layer	≥450	≥205	≥30	≥27

Nickel-Based Alloy Cladding Layer	≥550	≥240	≥30	≥27
Cobalt-Based Alloy Cladding Layer	≥600	≥250	≥25	≥27
Tungsten Carbide Cladding Layer	≥700	≥300	≥15	≥20

4.13 最终尺寸检验 / Final Dimension Inspection

4.13.1 检验内容 / Inspection Content

热处理完成后，应对法兰进行最终尺寸检验，检验内容包括：

After heat treatment is completed, final dimension inspection shall be performed on the flange, with inspection content including:

- 法兰外径、内径
- 法兰厚度
- 螺栓孔直径、位置度
- 堆焊层总厚度
- 法兰平面度
- 法兰密封面粗糙度
- Flange outer diameter, inner diameter
- Flange thickness
- Bolt hole diameter, position tolerance
- Total cladding layer thickness
- Flange flatness
- Flange sealing surface roughness

4.13.2 合格标准 / Acceptance Criteria

检验项目	合格标准
外径	符合图纸要求，偏差≤±0.5mm
内径	符合图纸要求，偏差≤±0.5mm
厚度	符合图纸要求，偏差≤±0.5mm
螺栓孔直径	符合图纸要求，偏差≤±0.2mm

螺栓孔位置度	符合图纸要求，偏差≤±0.5mm
堆焊层总厚度	符合图纸要求，偏差≤±0.5mm
平面度	≤0.5mm
密封面粗糙度	Ra≤3.2μm

Inspection Item	Acceptance Criteria
Outer Diameter	Comply with drawing requirements, deviation ≤±0.5mm
Inner Diameter	Comply with drawing requirements, deviation ≤±0.5mm
Thickness	Comply with drawing requirements, deviation ≤±0.5mm
Bolt Hole Diameter	Comply with drawing requirements, deviation ≤±0.2mm
Bolt Hole Position Tolerance	Comply with drawing requirements, deviation ≤±0.5mm
Total Cladding Layer Thickness	Comply with drawing requirements, deviation ≤±0.5mm
Flatness	≤0.5mm
Sealing Surface Roughness	Ra≤3.2μm

4.14 成品外观检验 / Finished Product Appearance Inspection

4.14.1 检验内容 / Inspection Content

- 堆焊层表面质量：无裂纹、气孔、夹渣等超标缺陷
- 堆焊层成型质量：波纹均匀，过渡平滑
- 法兰整体外观：无磕碰、划伤等机械损伤
- 标识检查：产品标识清晰、完整
- Cladding layer surface quality: No excessive defects such as cracks, porosity, inclusions
- Cladding layer formation quality: Uniform ripples, smooth transition
- Flange overall appearance: No mechanical damage such as dents, scratches
- Marking inspection: Product marking clear and complete

4.14.2 合格标准 / Acceptance Criteria

- 堆焊层表面无超标缺陷
- 堆焊层成型良好
- 法兰整体外观良好
- 产品标识清晰、完整
- No excessive defects on cladding layer surface
- Good cladding layer formation
- Good flange overall appearance
- Product marking clear and complete

5. 监督考核 / Supervision and Assessment

5.1 检验记录管理 / Inspection Record Management

- 所有检验记录应真实、准确、完整
- 检验记录应按规定保存，保存期限不少于产品寿命周期
- 检验记录应可追溯，便于质量追溯
- All inspection records shall be true, accurate and complete
- Inspection records shall be preserved as required, with preservation period not less than the product life cycle
- Inspection records shall be traceable for quality traceability

5.2 不合格品处理 / Nonconforming Product Handling

- 检验过程中发现的不合格品，应按《不合格品控制程序》处理
- 不合格品的返工、返修应经技术部门确认
- 返工、返修后的产品应重新检验
- Nonconforming products found during inspection shall be handled according to the "Nonconforming Product Control Procedure"
- Rework and repair of nonconforming products shall be confirmed by the technology department
- Products after rework and repair shall be re-inspected

5.3 检验人员要求 / Inspector Requirements

- 检验人员应经过专业培训，持证上岗
- 检验人员应熟悉检验标准和方法
- 检验人员应公正、客观地执行检验工作
- Inspectors shall receive professional training and work with certificates
- Inspectors shall be familiar with inspection standards and methods

- Inspectors shall perform inspection work impartially and objectively

6. 附则 / Supplementary Provisions

6.1 相关文件 / Related Documents

- CLADDING-WP-001《大口径法兰堆焊焊接工艺规程》
- CLADDING-QP-002《不合格品控制程序》
- CLADDING-QP-003《检验记录管理程序》
- CLADDING-QP-004《设备管理程序》
- CLADDING-WP-001 "Large Diameter Flange Cladding Welding Procedure Specification"
- CLADDING-QP-002 "Nonconforming Product Control Procedure"
- CLADDING-QP-003 "Inspection Record Management Procedure"
- CLADDING-QP-004 "Equipment Management Procedure"

6.2 相关记录 / Related Records

- CLADDING-FM-018-01《基材检验记录表》
- CLADDING-FM-018-02《焊材检验记录表》
- CLADDING-FM-018-03《层间温度控制记录表》
- CLADDING-FM-018-04《层间清理记录表》
- CLADDING-FM-018-05《外观检验记录表》
- CLADDING-FM-018-06《尺寸检验记录表》
- CLADDING-FM-018-07《热处理记录表》
- CLADDING-FM-018-08《硬度检测报告》
- CLADDING-FM-018-09《化学成分分析报告》
- CLADDING-FM-018-10《力学性能试验报告》
- CLADDING-FM-018-11《最终检验记录表》
- CLADDING-FM-018-12《成品检验报告》
- CLADDING-FM-018-01 "Base Material Inspection Record"
- CLADDING-FM-018-02 "Welding Material Inspection Record"
- CLADDING-FM-018-03 "Interlayer Temperature Control Record"
- CLADDING-FM-018-04 "Interlayer Cleaning Record"
- CLADDING-FM-018-05 "Appearance Inspection Record"
- CLADDING-FM-018-06 "Dimension Inspection Record"
- CLADDING-FM-018-07 "Heat Treatment Record"
- CLADDING-FM-018-08 "Hardness Test Report"
- CLADDING-FM-018-09 "Chemical Composition Analysis Report"

- CLADDING-FM-018-10 "Mechanical Property Test Report"
- CLADDING-FM-018-11 "Final Inspection Record"
- CLADDING-FM-018-12 "Finished Product Inspection Report"

6.3 修订记录 / Revision History

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